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Mission Operations Support Area (MOSA) for Ground Network Support

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The Mission Operations Support Area has been designed utilizing numerous commercial off the shelf items (see Figure 1), when possible, providing ease of maintenance and upgrade-ability. At its inception, all equipment was at the fore-front of technology. The system was created to provide the operator with a 'State of the Art' replacement for equipment that was becoming antiquated and virtually impossible to repair with new parts because of unavailability. Although the Mini-NOCC provided adequate support to the Network for a number of years, it was quickly becoming ineffectual for higher data rate and non-standard missions. The MOSA will prove to be invaluable in the future as more and more missions require Ground Network support.

For the past several years, NASA has provided Operational and Technical support to its Ground stations utilizing the Mini-NOCC telemetry, command, tracking, range safety, and log/delog data systems shown in Figure 2. Specific functions include, station sub-system verification, system verification, Mission support verification, personnel proficiency training, mission support validation, and pre-mission, mission, and post mission fault isolation and analysis. These functions are provided for Space Shuttle, Expendable Launch Vehicles (ELV), and their payloads as well as station changes and upgrades.

Early in 1990 the Small Explorer project requested the assistance of the Networks Division in providing these support functions for a series of ground supported high data rate CCSDS compatible payloads. With the current Mini-NOCC being restricted to 224kb data streams and unable to process CCSDS recommendations, it was evident that not only a more enhanced data system would need to be developed to meet these requirements, but this new system must be designed and

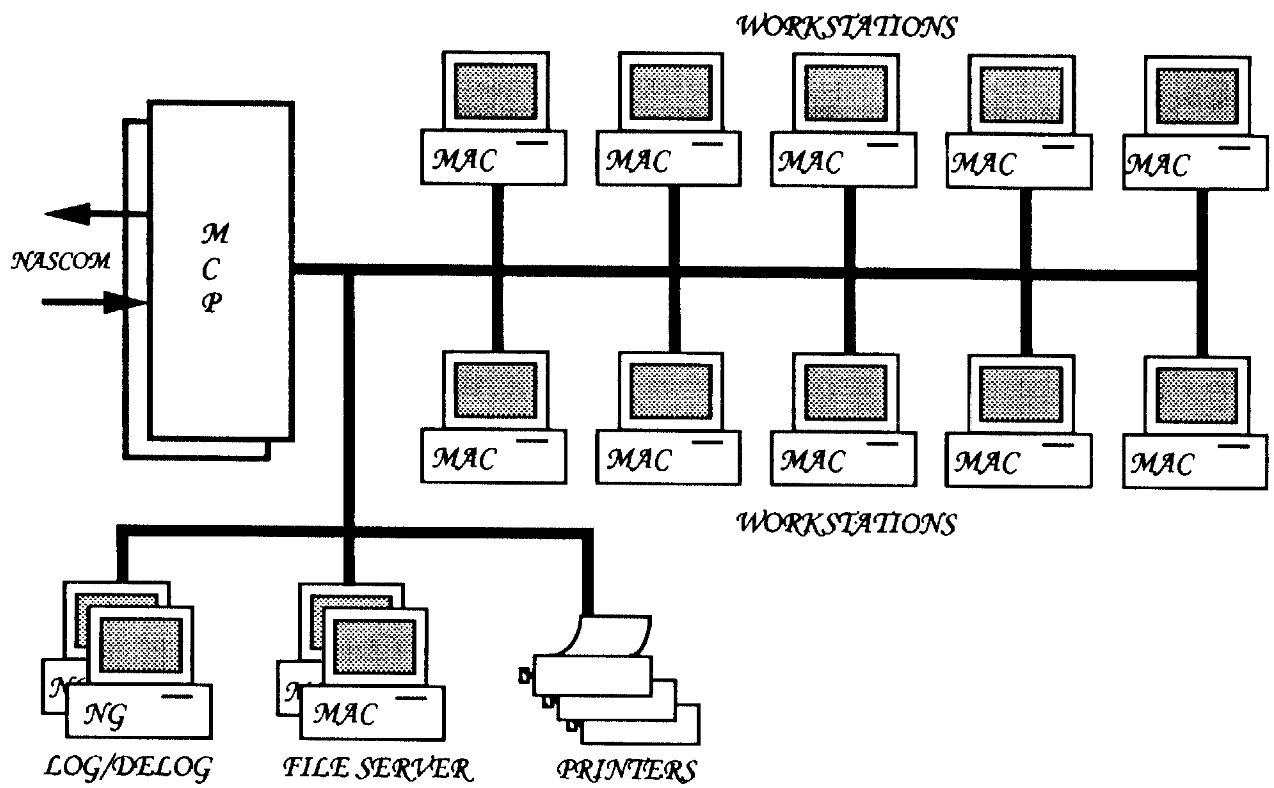

Figure 1. MOSA Basic Plan

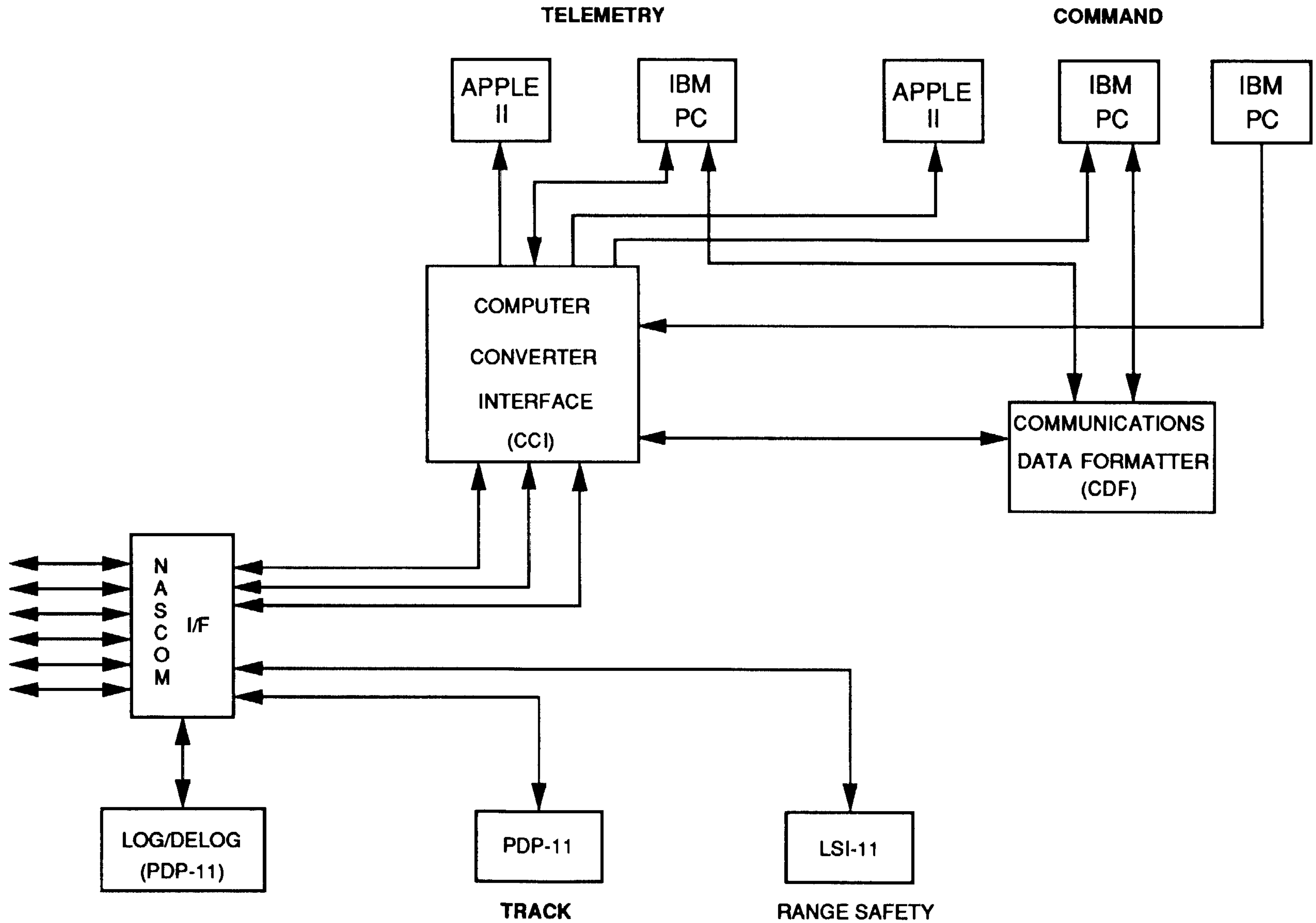

Figure 2. Mini-NOCC Configuration

implemented in a relatively short period of time in order to meet the established SMEX mission manifest. With a challenge of this magnitude, it was decided that a team of qualified engineers from both NASA and AlliedSignal Technical Services (ATSC) be formed to tackle the project. Thus came in to being, the Mission Operations Support Area (MOSA).

After investigating all avenues, a final design was agreed upon. The design, as reflected in Figure 3, consisted of multiple workstations tied together via an Ethernet interface to an intelligent Front End Processor controlling all incoming and outgoing data. Each workstation would consist of a Macintosh or PC based system with dedicated video monitors. Ten identical Macintosh workstations would be utilized as the basic support system providing telemetry, command, and track functions. The log/delog system would be comprised of two Northgate 486 PC's and hard drives capable of logging 1GBytes of data. In addition to these workstations, it was decided to incorporate another to act as a system file server that could be used as a massive system data base providing multiple system and program aides. To accommodate the system, new consoles had to be designed and fabricated. And to further assist in meeting the projected mission timeline, the decision was made to relocate the MOSA instead of interfering with ongoing mission support in the Mini-NOCC.

The following paragraphs describe in high level detail individual MOSA sub-systems and their relationship to each other and the overall system concept.

MOSA COMMUNICATIONS PROCESSOR

The MOSA Communications Processor (MCP) provides the interface to all external Nascom circuits. Two redundant MCP's were developed around a Motorola 32MHz MC68030

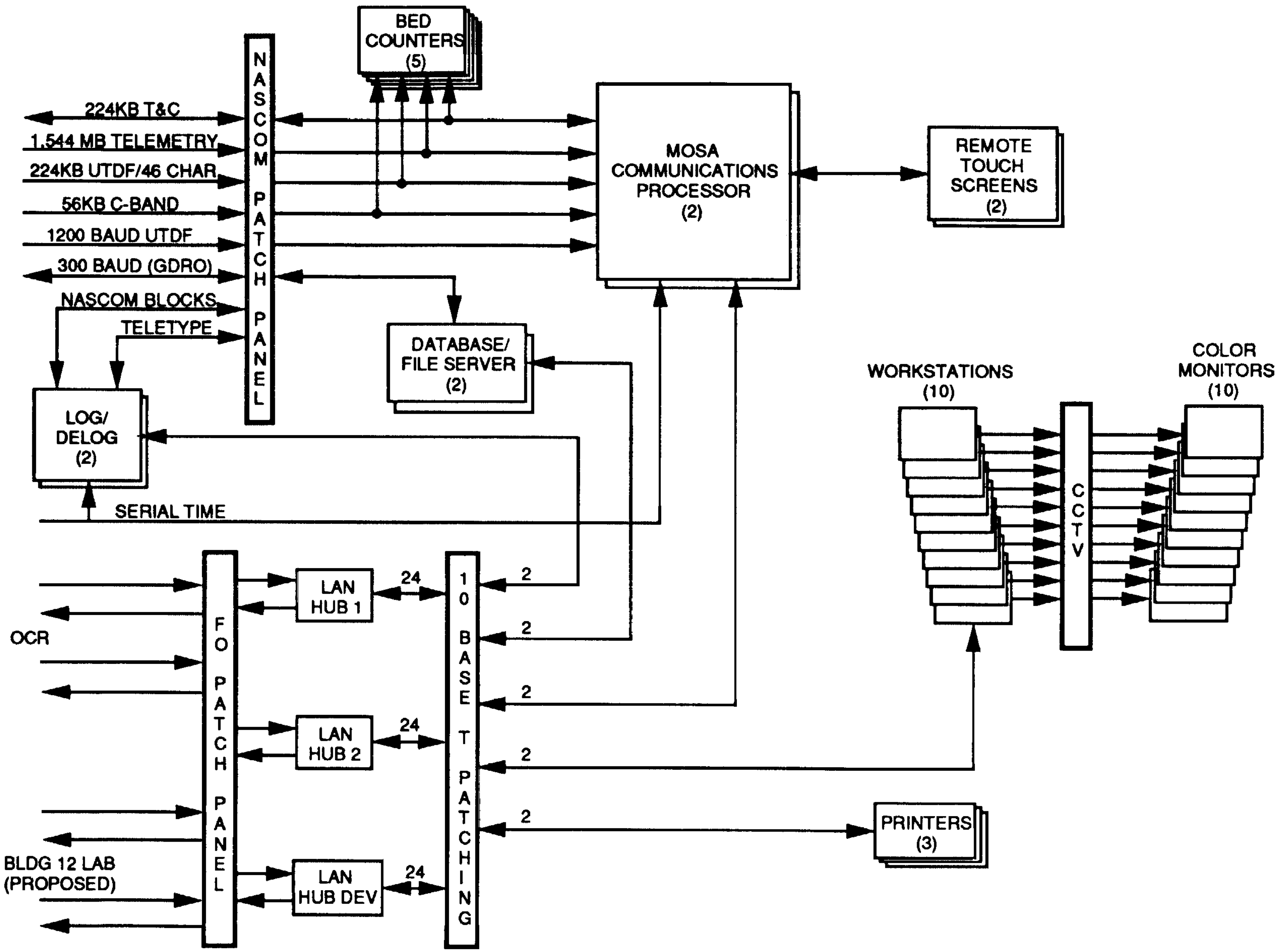

Figure 3. MOSA Detailed Block Diagram

microprocessor with 16 Mbytes of RAM for subsystem communication. Of the two processors within each MCP, reference Figure 4, one acts as the master controller while the other is the slave. The master processor controls all communications to the workstations, maintains the subsystem data requests, and controls the status and diagnostic displays at each console. The slave processor analyzes the data as it is received, builds the frames of data for display, receives the asynchronous tracking data, and coordinates diagnostic testing. The MCP stores the analyzed data internally and provides it to the workstation upon request.

The operator control of the MCP is provided by touch screens. The touch screens are composed of plasma displays with infrared sensors located around the perimeter of the screen for sensing the menu selection made by the operator. The touch screens are located not only on the front of the MCP but also remotely from each console position. All touch screen functions are available, regardless of which display the operator utilizes. The MCP initializes the touch screen with the MCP identification number, the software version, the current GMT, provided by the internal Bancomm timing decoders, and the elapsed time from MCP activation. The MCP identifies which Macintosh workstations are currently configured to the MCP along with an incrementing counter for network messages transmitted to and received from the workstation. The same display will provide the time at which the Macintosh activated the connection and the number of windows active at that position. The system errors are displayed at the bottom of the main screen but can be expanded to thirteen lines with scrolling capabilities. The errors are identified and tagged with corresponding block time. The diagnostic display provides an analysis of the Intelligent Transmit/Receive boards. The test is configured

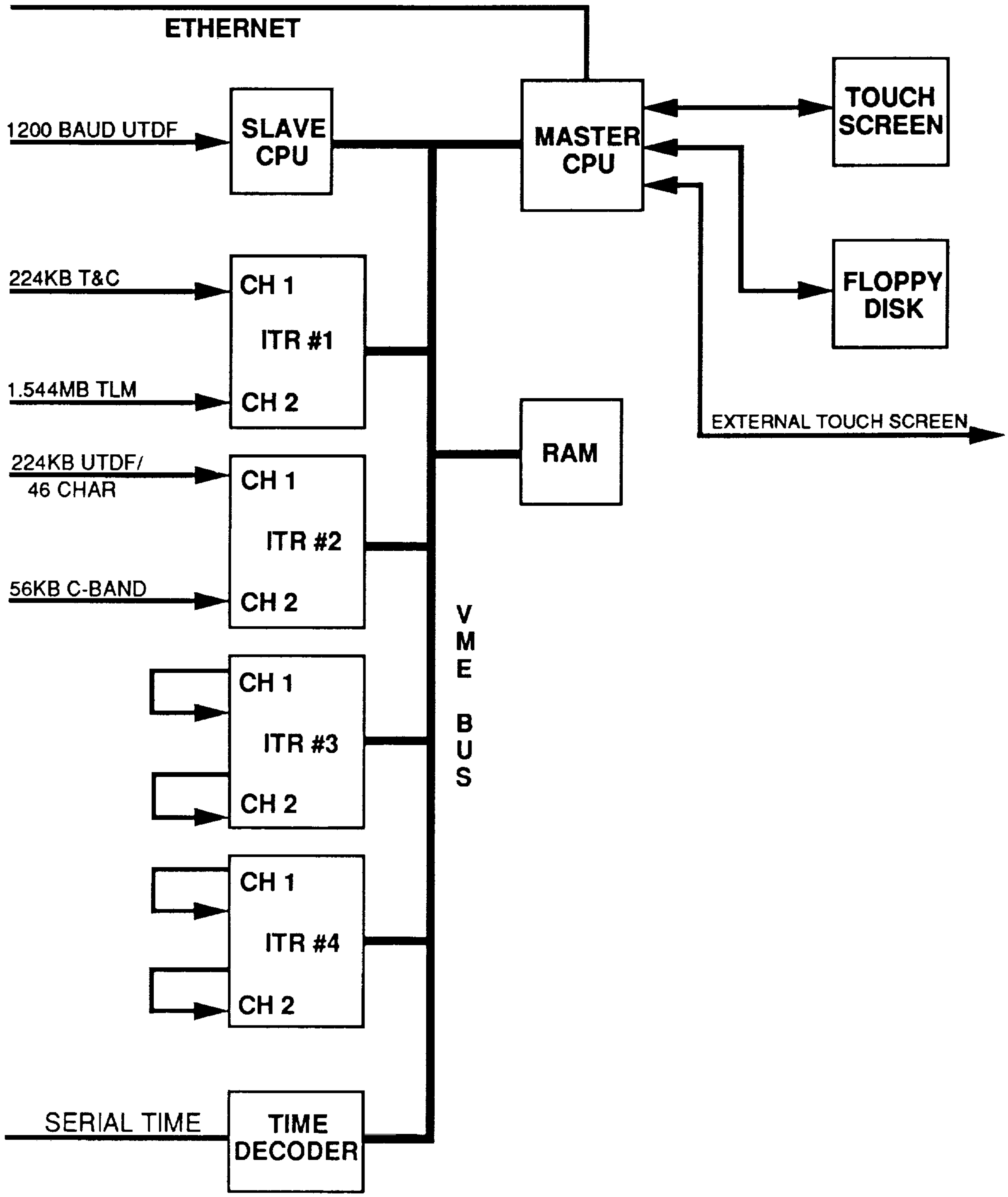

Figure 4. MCP Configuration

with a specific transmit port, receive port, clock rate, and receiver time out. The system performs a bit error rate check on the ports and delivers the results to the operator for analysis. The data connection display identifies which of the Input/Output (I/O) ports are active according to the stream name and/or clock activity. In addition to counting the number of elements received and transmitted, the MCP counts the number of Cyclic Redundancy Check (CRC) errors received on each channel. The system is capable of resynchronizing a stream of telemetry data in any standard format as well as CCSDS data up to 1.544 Mb/second. The MCP is capable of handling up to eight full duplex Nascom lines.

Within the MCP, Intelligent Transmit/Receive (ITR) boards are installed to provide an interface to Nascom equipment. These boards, designed and developed by NASA, communicate channel activity to the MCP's and to the workstations. The configuration is demonstrated in Figure 5. Each board provides full duplex synchronous channels for interfacing to NASCOM and resynchronizing telemetry. The board is a Harris RTX2000 micro controller programmed in Forth assembly language. Each transmit board can handle synchronous blocks up to 65536 bytes in length. This makes the boards practical for both Nascom blocked data and telemetry frames. CRC polynomials are generated by the ITR and inserted at the end of the Nascom blocks and telemetry frames. The transmit (or receive) clock can be externally supplied, internally created by the frequency synthesizer, or from a selected clock on another transmitter. The ITR receive capability is also 65536 bytes in length. Two 64-bit digital correlators allow detection of the selected synchronization pattern with programmable data and mask patterns and an allowable number of errors. The correlators operate in parallel to allow the detection of both true and inverted frame sync patterns. The receive channel on the ITR will also detect and correct for a

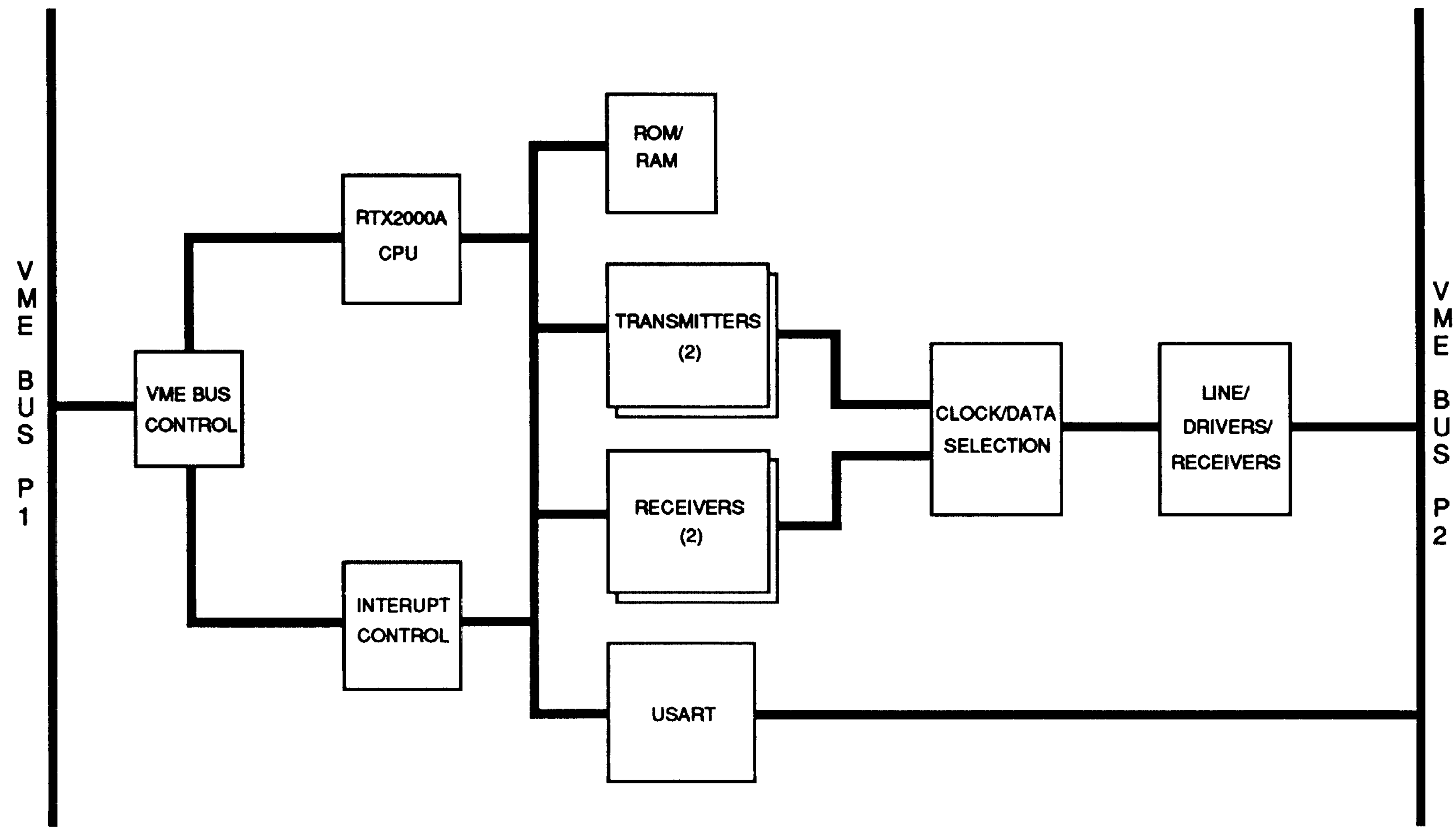

Figure 5. ITR Block Diagram

bit slippage of up to one bit in either direction. Receive CRC or Nascom polynomial errors are detected and reported to the MCP.

MOSA WORKSTATIONS

The Apple Quadra workstations replace the Apple IIe and IBM computers in the Mini-NOCC. The workstation is the primary operator interface in the MOSA data system. The operating system is Apple Computer's System 7. The MOSA software developed by NASA is the processing software that allows the user to interact with the database/server, log/delog, and MCP. The software was developed utilizing MacApp and C++ along with the importation of applications previously developed for existing station equipment. Upon launching the MOSA icon, an MCP connection must be chosen. If the operator later wishes to connect to the other MCP, the MOSA application must be ended and restarted. No connection is an option if the user is creating and storing data monitoring configurations for future use.

The MOSA software is a combination of all the functions previously supported by the Mini-NOCC (with the exception of Air-to-Ground). The operations are sorted into Block, Telemetry, Shuttle, CCSDS, Acquisition/Track, Range Safety, Command and general status information. Whenever a processing window is selected from the menus, the operator is prompted for the stream configuration information. The amount of parameter information requested depends upon the level of analysis.

The Block function processes Nascom 4800 bit blocks. A block show will display all blocks which meet the configuration criteria starting with the Nascom sync pattern. The scroll bars enable the user to examine the block in its entirety.

The block statistics window will process the indicated Nascom blocks and provide summary information. The information includes the number of blocks accepted, PEP errors, sequence errors, missed blocks, delta time errors, and Nascom frame sync bit errors. Counters in any statistic window can be reset individually or globally.

The Telemetry operation includes a frame show which displays the frame time and the raw frame starting at the frame sync. The telemetry frame statistics window processes the selected stream and indicates lock status, inversion, frames expected, frames accepted, true/inverted syncs, sync dropouts and frame sync errors. These two windows are specifically for throughput telemetry.

To support the shuttle program, several shuttle specific displays are required. An Operational Downlink (OD) show window displays the telemetry with subframe information. The Space Shuttle Main Engine (SSME) analysis tracks the number of valid frames and errors received for each engine along with a display of the frame its self. A statistical display of the data received from the stations gives the operator a quick view of the station performance. On another set of displays, the command, telemetry, and track site status messages (SSM's) are translated in alphanumeric values and displayed in full by scrolling through the window.

The CCSDS functions include both telemetry and command processing. The telemetry frame show and telemetry frame statistics windows are comparable to the throughput telemetry windows described previously. The CCSDS telemetry frame statistics window additionally includes counters for the number of frames and packets received relative to their virtual channel identifier. The telemetry frame header, telemetry packet header, command frame header, and command packet header windows translate the header information into alphanumeric information based upon the corresponding CCSDS standard. The telemetry frame show, telemetry packet show, command frame show, and command packet show display the selected segment (frame and packet) of raw data for the given stream. The telemetry packet statistics displays the block, frame, and packet times along with the quantity of each application ID received in the telemetry stream. Once enabled, the lock/search history will annotate the actual GMT times for lock and loss of lock on a designated stream. The Command Link Transmission Unit (CLTU) statistics evaluates the telemetry stream. The CLTU portion of the stream is translated while the number of blocks received and the number of invalid CLTU's are counted. The Command Link Control Word (CLCW) display provides the parameters in alphanumeric symbols. The scrolling portion of the display contains the CLCW in raw format with GMT of receipt. Finally, the command history window contains a scrolling area for listing the command application ID, the commanded function ID, and the block time of the command.

The Acquisition/Track function processes all incoming tracking data for selection by the operator. The track status window indicates which tracking data types are being received and from which station the data originated. Valid data is written in green. A stream that has dropped out or has been interrupted will go to red for two minutes, then the stream will drop from the display list. An invalid LTAS stream will be displayed in black with only the valid bits displayed. Clicking on one of these listed streams will activate the tracking summary window. The track or Launch Trajectory Acquisition System (LTAS) summary window will translate the data selected into detailed alphanumeric displays. The summary windows can also be accessed directly from the Acq/Trk menu. If the window is selected from the menu, the operator will be requested to choose the data for processing from a list of incoming streams. The options window allows the operator to select the parameter units for range, Doppler, and the angle coordinates. The track comparison window prompts the operator to select an acquisition message with which to compare the incoming tracking data. The message is computed and derived for the relative time found in the tracking data and then parameters are compared to the incoming station data. The transmit acquisition message window allows the selection of an acquisition message from the server database. The operator then selects which destination router is necessary for this message. The transmit button enables the sending routine.

Range safety processing is a detailed analysis of the 2.4 Kb streams utilized during ELV and Shuttle supports. The data is evaluated and displayed in alphanumeric format to enable rapid realtime analysis. The parameters are specified with the appropriate units. This function also has the capability to display the analog parameters within the stream as digital Cathode Ray Tube (CRT) strip chart signals. This process was originally performed with physical analog strip chart equipment provided specifically for this task.

Scientific spacecraft commanding allows the operator to transmit test commands to the stations and POCC's for verification. The commands are designed and created by the operator to match the POCC command structure. The transmit window will also confirm the validity of the station's command echo block. The Shuttle command function provides unencrypted modulation to the station and locks on the station's command echo. The modulation can be clocked internally or externally. A transmit window sends a command through the modulation for verification in the command echo portion of the window.

Further functions adapted from other systems in existence include the error history and the watch panels. The error history tracks the processing errors reported by the MOSA software and the MCP along with the time of their occurrence. The watch panels allow the operator to select a specific bit or group of bits to monitor within the block, frame, or packet. This utility greatly reduces the time spent manually delogging data or trying to see bit values on a constantly updating show window.

Unique capabilities are created under the MOSA software application. Since the capabilities are useful to all windows and operations, they are grouped under File and Tool menus. The MOSA software allows the user to configure a window and save the file under a descriptive name for use during operational support. When one opens a saved file, the software requests a confirmation of the configuration and then activates the window without additional entries. the print show operation will print to the Apple Laser writer the entire block or frame which is currently displayed in the active show window. The configure function supplies the configuration menu for the selected window in order to update the parameters for processing. Freeze/thaw will pause/ restart the processing of the active window. The refresh rate or how often a window is updated can be increased and decreased, although this function is also affected by the number of windows open on the workstation. Specific warning messages are provided by the MCP to the workstation to alert the operator when changes are made to the MCP that will effect the workstation's current operations. A function is available to disable the warning windows but an audible alarm is still provided. Finally, the MCP can be configured to allow the processor to lock on a frame sync with a few incorrect bits. This effects all block synchronization that the MCP does and therefore, effects all other workstations configured to this processor.

MOSA LOG/DELOG

The MOSA Log/Delog element replaces the PDP-11/24 system originally used in the Mini-NOCC. Two Northgate 486DX 33MHz computers have the capability of logging Nascom blocked data and low speed teletype traffic. Each system contains two Nascom Interface Boards (NIB) and a timing board. the programs are created in a DOS environment with the Borland "C" compiler. The logger requires the use of MX, or Multitasking Executive, which was developed initially for the Telemetry and Communications Data System located at the NASA tracking stations in Bermuda and Merritt Island, Florida. This multitasking environment will allow the unit to log incoming data and also playback data, in separate operations, for the user. The 1 Gbyte hard disk drive is segmented for data storage. The high speed active area is used to log and store Nascom blocked data. This is the largest area since it is also designed to meet the requirement to log at least five minutes of 1.544 Mbyte data. The low speed active area is used to store the teletype tracking data. The last portion of the disk is set aside for the archive areas. These locations allow the operator to save previously logged data and prevent overwrite by another logging activity. Six of the archive areas are designed to hold 15 minutes of 224Kb data, and the seventh area is dedicated to protecting five minutes of the 1.544 Mb/second recorded data. An area has been allocated to provide directory information to the operating programs. The hardware allocation is designed to reduce time-consuming disk head movement and to reduce file segmentation.

To begin a logging operation, the user selects either a Nascom or serial port. For a Nascom port, the software identifies delimiters that may be set by the operator or left blank. This allows the system to identify selected blocks on a port that may be receiving multiple data streams from multiple sources. Start and stop times are selectable, otherwise, all blocks received, which meet the criteria, are logged. If the logging operation is at a T1 rate (1.544 Mbytes), all other logging operations are canceled to dedicate all the system resources to the high rate operation. If a serial port is chosen for the logging operation, delimiters are not available and the system will promptly begin logging all data that arrives at that port. A message in the status area is provided to indicate when the active area is in danger of being overwritten. This allows the operator to write the data to an archive area before it is lost. The status area also briefly indicates which ports are logging and if any CRC errors were received at that input. The main menu provides a short display of all sessions in the high/low speed areas and a quick directory of the archive locations. A selection of one of the sessions or locations will provide a more detailed description including the delimiter parameters and the exact block times within the session.

The playback operation simply places data from either the active or the archive areas directly to the MCP or on the system Ethernet for use at the MOSA workstations. After selecting a session ID or a specific archive area, the operator selects a port and the recorded start/stop times of the data to be transmitted. The playback can be set for transmission at the original rate of the data, the maximum rate for the port, or a user defined rate. For Nascom blocks, the option is available to use an external or an internal clock. If an internal clock is selected, several choices are provided or the user can specify the rate. Nascom blocks can also be selected by header parameters (or delimiters) during playback. The status window will update to reflect the configuration for the playback with a continuous monitor until the activity is complete.

To delog the data, a separate program is initiated. This program is again written in "C" language. The archive or active area is selected and the recorded start/stop times identified. For Nascom blocks, delimiters are available. The operator has the choice of reviewing the data on the screen, sending it to the printer, or both. The printing and display format is selectable between hexidecimal, decimal, or octal. A delog to the screen will display the configuration at the top of the screen and the blocked data below. The blocks can be stepped through manually or allowed to update at the system rate. Printouts are designed to ensure that a full block is displayed on one page for operator ease of analysis.

MOSA FILE SERVER

The MOSA File Servers are Macintosh Quadra 950 computers running the 4D Client application. The server is accessible remotely from any of the workstations. Each server is independent, but data files can be copied by the operator from one server to the other for backup purposes. The server stores databases and program lookup tables. The operator has the ability to review the databases and in specific instances update the information. To access these databases a server is selected, and the server will prompt the operator for a limited access password. The access level is determined by the system administrator. Once logged to the server, the port status window indicates the activity of the server serial port that is receiving the acquisition data or teletype. The server status window annotates the number of messages received according to message class. These two windows provide evidence of the server's current standings. Under the database menu are the lookup tables and databases. Each of the database menu items allows the user to create, edit, review, and delete by record (according to access privileges).

The database concepts are particularly important for the tracking program. The tracking acquisition data is automatically stored into a database by way of the serial port. The outdated messages are deleted according to the same criteria utilized by the NASA Ground Network tracking systems documented in the STDN 724. This database allows the user to update acquisition messages according to the needs of the operational environment. As a result, the system allows a retransmission of an acquisition message for purposes of exercising the station tracking and acquisition procedures and configurations, along with generating and transmitting test acquisition data.

The lookup tables maintain information for the MOSA workstation software. The site geodetics, spacecraft identifier/vehicle identifier, station mnemonics, teletype routers, and telemetry configuration parameters are all set values that are provided in lookup tables instead of requiring the operator to enter this data each time it is needed.

The server also stores incoming teletype administrative messages. This database is utilized by the operators to retrieve Briefing Messages, Documentation Change Notices (DCN), Software Support Instructions (SSI), Interim Support Instructions (ISI), and many other operational messages. The teletype is distributed into relevant categories for easy access by any operator.

Operational documentation is also stored on the server and updated with a word processor as changes are received. Therefore, the latest information is always available by accessing the systems server.

In closing, the MOSA has been designed to enhance NASA's required support to the Ground Network system. The design will easily transition into normal system sustaining. In most cases the actual operators will be able to add functionality for new standardized missions. Though non-standard formats will require software and hardware modifications depending upon specific mission requirements.

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